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DISEASE DETECTION SURVEY
Air Pollution

Aztec Ruins National Monument
Aztec, New Mexico

Mesa Verde National Park
Mesa Verde, Colorado

By
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In August 1971, Robert Loomis, plant pathologist in the Forest Service Insect and Disease Branch, examined trees and associated plants on selected areas of Mesa Verde National Park, Colorado, and Aztec Ruins National Monument, New Mexico. The purpose of the survey was to determine if acute injury had occurred to trees and associated plants from SO_2 emitted by the Four Corners Power Generating Station near Farmington, New Mexico. No plant symptoms were found in any of the examined areas which could be attributed to SO_2 injury.

Method.--A detection system, consisting of four vegetative observation areas and sulfation plate stations at Mesa Verde (Fig. 1), and one observation area and sulfation plate station at Aztec Ruins, was initiated in September 1970. Where possible, the sulfation plate stations and observation areas were established together in species type and location most susceptible to SO_2 injury. By locating the sulfation plates and vegetative observation areas together, we may be able to determine if there is a relationship between sulfation rate and the presence or absence of plant injury. By finding areas most susceptible to SO_2 injury, the detection system is made more sensitive to possible SO_2 injury.

Considerations for establishing observation areas include:

1. Presence of a variety of trees and associated plants growing in the area. One phase on evaluating possible SO_2 injury to plants is to determine if similar injury had occurred to a variety of plant species.

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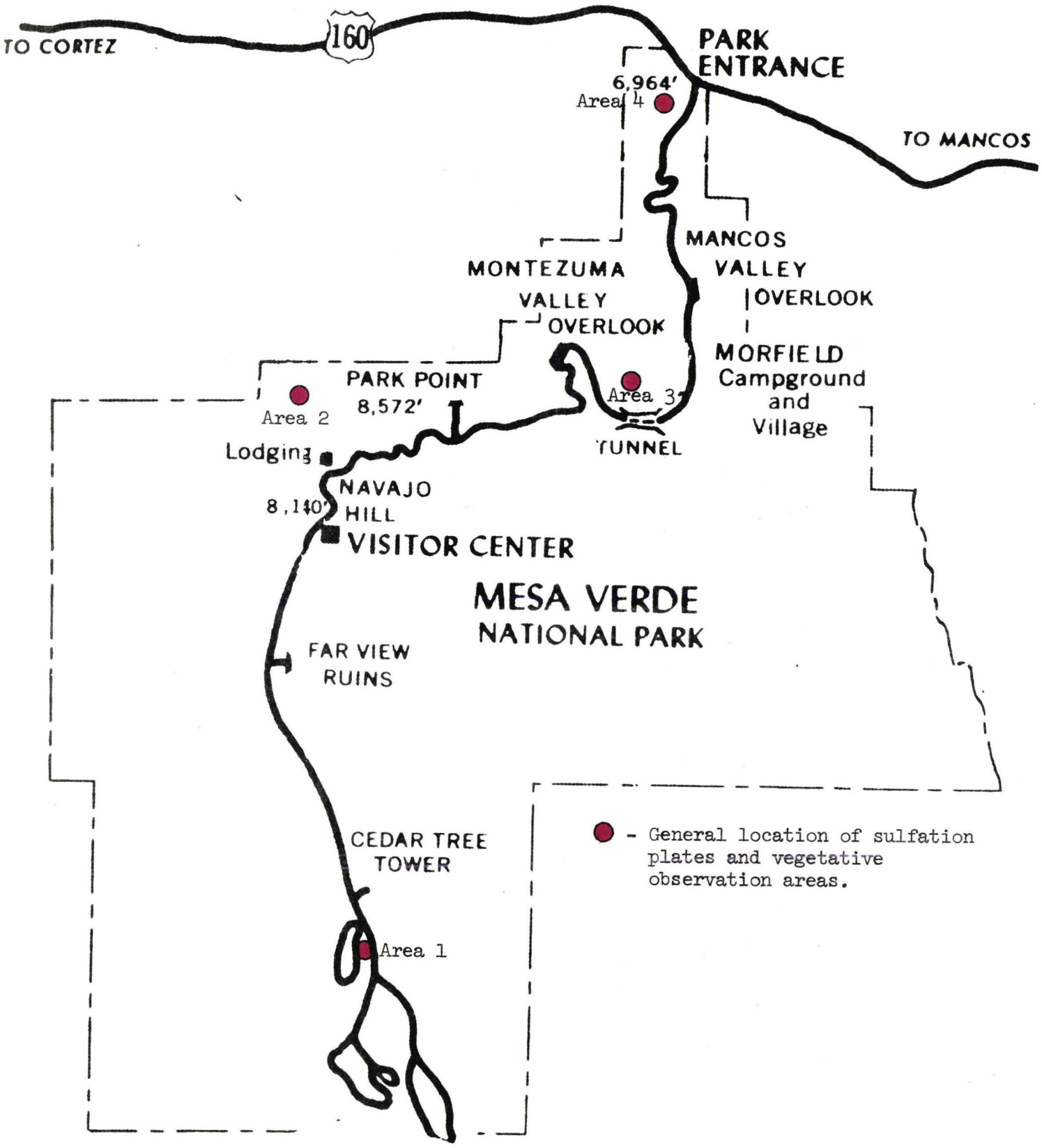
Fig. 1.--Location of sulfation plates and vegetative observation areas, Mesa Verde National Park, September 1971.



2. The observation areas should have adequate soil moisture. Plants growing in areas with adequate soil moisture and high humidity are more susceptible to SO_2 damage than plants growing under arid conditions.

The foliage of trees and associated plants was examined for the interveinal bleaching, interveinal necrosis, and tip burn typical of acute SO_2 injury. In addition, leaf and needle abnormalities from other causes were noted for future reference.

Results (Mesa Verde National Park).--The following plant species were examined for evidence of acute SO_2 injury:

Forest Trees

Douglas-fir (*Pseudotsuga menziesii*)
Aspen (*Populus tremuloides*)
Ponderosa pine (*Pinus ponderosa*)
Pinyon pine (*Pinus edulis*)
Juniper (*Juniperus* spp.)
Gambel oak (*Quercus gambelii*)
Wild cherry (*Prunus* spp.)
Box elder (*Acer negundo*)

Forest Plants and Shrubs

Serviceberry (*Amelanchier* spp.)
Wild currant (*Ribes* spp.)
Wild rose (*Rosa* spp.)
Poison ivy (*Toxicodendron radicans*)
Mountain mahogany (*Cercocarpus* spp.)

No symptoms of acute SO_2 injury were found on trees and plants in any of the four observation areas. Tree and plant condition was noted as follows:

1. Wild cherry tree foliage in the vicinity of observation area 1 (Spruce Tree Canyon) had a bleached appearance caused by lace bug (family Tingidae) feeding. No lasting effect from this injury is expected.

2. The uredial stage of a rust fungus was noted on wild currant in observation area 1. This rust fungus is probably *Coleosporium jonesii*, a common needle rust of pinyon pine, which has an alternate host of wild currant or gooseberry (*Ribes* spp.). This rust is endemic in the area and causes little damage.

3. Gambel oak leaf injury, caused by insect feeding, was noted in observation areas 1 and 3. Insects causing this leaf skeletonizing injury cause little or no lasting damage to the infested trees.

Sulfation plate data for the period September 1970-October 1971 are as follows:

Area 1 - Mesa Verde National Park

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Sep. 1970	22	5.3
Oct.	32	1.1
Nov.	29	1.6
Dec.	34	** < Detectable minimum
Jan. 1971	25	3.7
Feb.	31	< Detectable minimum
Mar.	31	4.1
Apr.	29	3.0
May	31	< Detectable minimum
Jun.	34	< Detectable minimum
Jul.	28	< Detectable minimum
Aug.	-	-
Sep.	29	< Detectable minimum
Oct.	30	< Detectable minimum

Area 2 - Mesa Verde National Park

Sep. 1970	22	< Detectable minimum
Oct.	32	< Detectable minimum
Nov.	29	< Detectable minimum
Dec. & Jan. 1971	59	< Detectable minimum
Feb. & Mar.	59	1.5
Apr.	29	3.6
May	31	< Detectable minimum
Jun.	34	< Detectable minimum
Jul.	28	< Detectable minimum
Aug.	32	2.7
Sep.	29	< Detectable minimum
Oct.	30	< Detectable minimum

* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$)
Sep. 1970-Mar. 1971 - 1.2
Apr. 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

Area 3 - Mesa Verde National Park

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Sep. 1970	22	2.9
Oct.	32	** < Detectable minimum
Nov.	-	-
Dec.	34	< Detectable minimum
Jan. 1971	25	< Detectable minimum
Feb.	31	< Detectable minimum
Mar.	31	1.7
Apr.	29	3.0
May	31	< Detectable minimum
Jun.	34	< Detectable minimum
Jul.	27	< Detectable minimum
Aug.	32	4.1
Sep.	30	< Detectable minimum
Oct.	29	< Detectable minimum

Area 4 - Mesa Verde National Park

Sep. 1970	22	2.9
Oct.	32	1.5
Nov.	29	< Detectable minimum
Dec.	34	< Detectable minimum
Jan. 1971	25	2.3
Feb.	31	< Detectable minimum
Mar.	31	1.7
Apr.	29	3.0
May	31	< Detectable minimum
Jun.	34	< Detectable minimum
Jul.	27	< Detectable minimum
Aug.	33	2.6
Sep.	30	< Detectable minimum
Oct.	29	< Detectable minimum

* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$)
Sep. 1970-Mar. 1971 - 1.2
Apr. 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

Results (Aztec Ruins National Monument).--The following plant species were examined for evidence of acute SO_2 injury:

Elm (Ulmus spp.)
Cottonwood (Populus spp.)
Ash (Fraxinus spp.)
Willow (Salix spp.)
Sunflower (Helianthus spp.)

No symptoms of acute SO_2 injury were found on any of the trees and plants examined on the Monument grounds. A moderate to heavy infestation of elm trees by the elm leaf beetle, Pyrrhalta luteola, was noted. Past experience has shown that heavy infestations of elm leaf beetle repeated over several years have killed some trees which grow under environmental stress. Elm trees which get adequate care (i.e. water and fertilization) are not usually killed by elm leaf beetle infestation.

Sulfation plate data for the period September 1970-October 1971 are as follows:

Area 1 - Aztec Ruins National Monument

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Sep. 1970	21	2.2
Oct.	31	1.5
Nov.	29	** <Detectable minimum
Dec.	31	1.9
Jan. 1971	34	<Detectable minimum
Feb.	25	<Detectable minimum
Mar.	31	1.7
Apr.	30	2.9
May	31	<Detectable minimum
Jun.	30	1.3
Jul.	31	<Detectable minimum
Aug.	31	1.5
Sep.	30	<Detectable minimum
Oct.	31	<Detectable minimum

* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrigrams $SO_3/cm^2/day$)
Sep. 1970-Mar. 1971 - 1.2
Apr. 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

Discussion.--Diagnosis of air pollution injury to vegetation is complicated by environmental, insect, and other disease factors. These factors can cause leaf and plant symptoms which appear similar to air pollution injury. In addition, the occurrence or severity of air pollution-caused plant injury is determined not only by the pollutant concentrations and duration of exposure, but by many environmental factors which can affect individual plant sensitivity. These factors include light, moisture, temperature, and nutrient relations.1/

To date, the only places we have found acute SO_2 injury to Southwestern forest vegetation have been within 4 miles of the source emitting SO_2. Therefore, the lack of acute damage symptoms might be expected because Mesa Verde National Park and Aztec Ruins National Monument are more than 30 miles and 20 miles, respectively, from the Four Corners Power Station. A study prepared by the U.S. Department of Health, Education, and Welfare, Bureau of Abatement and Control,2/ suggests that plant damage is most likely to occur within a radius of 10 miles of the Four Corners Power Station, but that there is a possibility of detectable damage to sensitive vegetation located on the western edges of the Carson and Santa Fe National Forests. This document also suggests that during initial surveys, such as the one reported here, little or no damage may be discovered, but that the information obtained will be useful when evaluating the impact of additional power plant units in the Four Corners area.

Sulfation plates are being used to determine if SO_2 and other sulfur compounds are reaching the vegetative observation areas.3/ The sulfation plates are exposed for approximately 30 days, during which time sulfur compounds react with the lead dioxide in the plate. The product of these reactants is then measured and expressed as micrograms $SO_3/cm^2/day$.4/ This is commonly called the sulfation rate. Sulfation plate data show that most average sulfation rates are at

1/ Treshow, M. 1970. Environment and Plant Response. McGraw-Hill Book Co., N. Y. 422 p.
2/ Estimates of Air Pollution Concentrations from Four Corners Power Plant, New Mexico. 1970. Division of Control Agency Development, Bureau of Abatement and Control, U.S. Dept. Health, Education, and Welfare.
3/ Tucson Advisory Committee on Air Pollution. 1971. Air Pollution in Tucson: A Report to the Mayor and Council of the City of Tucson. Edited by R. Caldwell. 141 p.
4/ Huey, N. A. 1968. The Lead Dioxide Estimation of Sulfur Dioxide Pollution. J. Air Poll. Control Assoc. 18: 9.

or near rates which might be expected in areas remote from an SO_2 source. Levels of SO_2 and/or other sulfur compounds which produced measurable sulfation rates were not sufficiently high to cause acute plant injury in the observation areas. These plates provide an economical way of determining the general dispersion of total sulfur compounds, and, therefore, may prove useful in finding locations more susceptible to SO_2 injury. Eventually, it may be possible to develop an area plant hazard rating system based on average sulfation rates and relative susceptibility of native forest species.

In order to get some idea of sulfation plate reliability, duplicate plates were exposed in five locations in New Mexico and Arizona. The sulfation rates of several individual plate-pairs varied considerably; however, when all plate-pairs are considered, there is a highly significant correlation between the sulfation rates on each of the plate-pairs ($R = 0.697$ with 18 degrees of freedom). There is no significant difference between the average of the means of each set of plate-pairs ($T = 0.233$ with 18 degrees of freedom).

Attached is a map of Arizona and New Mexico showing how the detection system at Mesa Verde and at Aztec Ruins fits into the complete network established by the Forest Service Insect and Disease Branch.

Recommendations.--

1. Conduct detection surveys in both Mesa Verde National Park and Aztec Ruins National Monument in late summer of 1972 to see if any symptoms of acute or chronic SO_2 injury can be noted. (Air quality measuring equipment is operational at Mesa Verde National Park.)

2. Re-establish the sulfation plate network when the San Juan Electrical Generating Station, located at Waterflow, New Mexico, begins operation in July 1973.

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